# Evaluation of Commercially-Available Catch Basin Inserts for the Treatment of Stormwater Runoff from Developed Sites

## October 1995

## Prepared by the Interagency Catch Basin Insert Committee

King County Surface Water Management Division
King County Department of Metropolitan Services
Snohomish County Surface Water Management Division
Seattle Drainage and Wastewater Utility
Port of Seattle

## ACKNOWLEDGMENTS

# Executive Summary

*Growing concern over the impact of pollutants that are washed from paved areas in the urban environment has prompted regulatory agencies to examine new methods of stormwater treatment. Similarly, the private sector has recognized the need to develop new products and services that will help businesses and municipalities reduce their contribution to water pollution problems and meet environmental regulations. Among these products are devices designed to fit beneath storm drain inlets and remove pollutants from stormwater runoff. These devices are commonly referred to as "catch basin inserts".*

*Three local vendors have developed catch basin inserts and are currently marketing their products. These inserts range in cost from $100 to $1,500, may be configured with, or without oil absorbing media, and come in both standard and custom-fit models. While servicing the inserts is simple and requires no little or no special equipment, most manufactures are developing service programs for their customers.*

*Inspired by the simplicity and relatively low cost of these product, but uncertain about the performance and maintenance requirements of the products, staff representing five local agencies examined the use of catch basin inserts for the treatment of runoff from developed sites. The study focused on the ability of the inserts to remove pollutants, the hydraulic characteristics of the inserts, and estimation of maintenance needs. The intent of the study was to provide the participating agencies and their customers the information needed to make sound decisions concerning the use of catch basin inserts. Since catch basin insert technology is rapidly changing, the study focuses more on the technology in general, than on the performance of specific products.*

*The inserts studied were nominally effective at removing fine (silt and clay) sediment and associated pollutants. Since coarse particles are generally removed by the catch basin sumps used in most conventional system, the study team did not examine the removal of these materials (fine sand and larger). The team did however, observe that the insert were able to capture coarse material and debris, and recommends that inserts be used where the objective is to remove these materials. Specific situations in which coarse sediment and debris removal is desirable include construction sites, materials yards, upstream of oil/water separators and sand filters, and wherever the aesthetic character of a receiving water is a concern. Maintenance of inserts configured for sediment and debris removal will vary dramatically and will depend upon the nature of the site and use of source control best management practices (BMPs).*

*The insert varied in their ability to remove petroleum products. Removal rates for inserts in good condition ranged from 20 to 90 percent when exposed to oil concentrations that were near the high end for urban runoff. For most products, performance dropped off rapidly with use. Using a target efficiency of 50 percent, and an effluent objective of 10*

*mg/L, the maintenance interval for these products ranged from after nearly every rainfall event (1/2 to 3/4 inch of rain) to after five or more inches of rain, (or about six weeks).*

*Efforts to determine the effectiveness of the inserts at removing phosphorus and dissolved metals were limited; however, the data-collected did not indicate the inserts were able to remove these pollutants any more effectively than they removed sediment.*

*King County has used the results of this study in the development of Surface Water Design Manual and Water Pollution Prevention Manual. In the Surface Water Design Manual, catch basin inserts have been approved for oil control in high traffic areas. The Water Pollution Prevention Manual targets existing businesses and provides general guidance concerning the selection and use of catch basin inserts.*

*While catch basin inserts have limited applicability for stormwater treatment, and should not be used in place of source control BMPs, they could be a valuable part of an organization's pollution prevention plan. The development of new filter media, and improved structural designs, may increase the range of conditions in which these products are use. The greatest difficulties facing those developing catch basin inserts for stormwater treatment lay in the small physical space inside the catch basins, the tendency for sediment to clog or blind filter media, and the fluctuating nature of the flow. Agencies and organizations involved in the protection of water resources should continue to follow, and were appropriate, support the development of these products.*

# Evaluation of Commercially-Available Catch Basin Inserts for the Treatment of Stormwater Runoff from Developed Sites

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# CHAPTER 1 - INTRODUCTION

## 1.1 PURPOSE OF THE PROJECT

The emergence of commercially available devices designed to treat stormwater at catch basin inlets may provide an economical means of stormwater treatment. The rapid increase in the number of these devices (commonly referred to as catch basin inserts) has raised both hope and concern of stormwater managers in the Puget Sound basin. The proper application of this technology may enhance the community's ability to protect its water resources; however, the limited availability of independently derived information on the performance and maintenance needs of these products raises concern that they may be inappropriately used to the exclusion of other, more effective pollution control measures.

To better understand the uses and limitations of locally manufactured catch basin inserts, the Catch Basin Insert Committee (CBIC) was formed. The CBIC is comprised of representatives from the King County Surface Water Management Division, King County Department of Metropolitan Services, City of Seattle Drainage and Wastewater Utility, Snohomish County Surface Water Management, and the Port of Seattle. The CBIC member jurisdictions pooled resources to evaluate several commercially-available inserts that could be used to remove contaminants from urban runoff. This report presents the findings of this project as well as those of a related study conducted concurrently by the Port of Seattle.

The purpose of this report is to provide general information on the state of catch basin insert technology in general, rather than to evaluate and compare specific products. Where differences in products are evident, comparisons are drawn only to identify characteristics which may affect the performance of inserts rather than to promote one product over another. Indeed, catch basin insert technology is changing so rapidly that the products available may well have been modified or replaced since this report was prepared. It is hoped the reader will use the general information and observations provided in this report to improve their understanding of the benefits, limitations, and mechanisms associated with catch basin inserts and make wise decisions concerning their development, use, and regulation.

## 1.2 QUESTIONS ADDRESSED BY THE STUDY

The issues addressed by the study focus on three major areas: pollutant removal, hydraulic capacity, and maintenance. Specific questions associated with each of these areas of inquiry follow.

### 1.2A Pollutant Removal Questions

1. Do the inserts remove pollutants from runoff from developed sites?
2. Does an insert provide improved performance over the catch basin sump?
3. Are inserts similar in performance to currently accepted treatment best management practices (BMPs) such as wet ponds, grass swales, and constructed wetlands in new developments?
4. Are inserts suitable as retrofit treatment devices in existing developments?

### 1.2B Hydraulic Performance Questions

1. What is the maximum treatment capacity of the inserts?
2. What is the maximum overflow capacity of the inserts?
3. Will the inserts contribute to local flooding around drain inlets?

### 1.2C Maintenance Questions

1. How often must units be serviced?
2. What are the physical requirements associated with maintenance?
3. What is the acceptable disposal method of spent media and accumulated sediment?

## 1.3 STUDY APPROACH AND REPORT ORGANIZATION

The project was divided into three major tasks. Each task was related to an area of inquiry described above. These tasks were:
1. Evaluation of pollutant removal performance.
2. Evaluation of hydraulic performance.
3. Determination of maintenance requirements.

Tasks 1 and 2 were accomplished through a combination of bench testing and field observations. To the extent possible, these tasks were carried out in an empirical manner and were intended to provide quantifiable results. The experiments used to address Tasks 1 and 2 are described in Chapters 2 and 3.

Task 3 was addressed by reconciling concerns raised by maintenance staff with field observations and the empirical results obtained through Tasks 1 and 2. Maintenance concerns and information related to maintenance issues are presented in Chapter 4.

Additional analytical data were obtained to characterize the spent filter media and trapped sediments. These data supported both the pollutant-removal and maintenance portions of the study.

Chapter 5 provides the reader with recommendations concerning the selection and use of catch basin inserts by describing the potential uses and limitation of catch basin inserts, as well as desirable and undesirable design characteristics. This chapter represents the study team's opinions regarding the state of catch basin insert technology.

Chapter 6 addresses catch basin inserts from the perspective of the regulator and suggests options for performance criteria.


## 1.4 VENDOR INVOLVEMENT

To the extent possible, manufacturers of the inserts were involved in the study. Early in the study, the vendors were asked to fill out a questionnaire which provided the study team with basic information concerning the appropriate use and maintenance of catch basin inserts. In addition, the vendors were asked to provide any existing data on their products. This information was used in the development of the experimental design.

Before the inserts were tested, each manufacturer was provided with a draft of the quality assurance plan and asked to recommend changes to be certain their products would be fairly tested. In response to these recommendations several changes were made in the experimental design.

During the course of the study, manufacturer involvement was limited because of a legal conflict between two of the vendors. Specifically, vendors were not allowed to visit the unsecured field locations.

Once an initial set of pollutant-removal tests was completed, the manufacturers were provided with analytical results, and were invited to submit alternative configurations of their products for a second series of tests. Two of the three vendors opted to submit alternative configurations.

Once the draft report was completed, manufacturers were given a copy of the document and were asked to submit comments. Several recommendations from the vendors were incorporated in this final report. Manufacturers' comments on the final draft report are included in Appendix D.


## 1.5 INTRODUCTION TO CATCH BASIN INSERTS

At the beginning of the study, the CBIC was familiar only with products designed to hang from a drain-inlet frame. Since that time, several other products have been developed that are installed well below the drain inlet, taking advantage of the space available in the lower portions of the catch basin or sump. While these products may rightly be called "catch basin inserts," in this report this term is used only to describe the products tested, all of which are installed immediately beneath the inlet grate.

Before introducing the inserts used in the study, it is useful to understand common features of catch basin inserts. A few of these features are listed below, and are shown in the generalized catch basin insert shown in Figure 1. Design features to keep in mind as you read this report include:

- A structure which contains the treatment system.
- A means of suspending this structure from the drain-inlet frame.
- One or more treatment mechanisms which include sedimentation, absorption, filtration, or gravitational separation of oil and water.
- A primary outlet for water which has been treated.
- A secondary- or high-flow outlet, through which water which exceeds the treatment capacity of the system may escape.

It should be noted that while all of the inserts allow stormwater to exit the system via an overflow when the flow rate exceeds the hydraulic capacity of the treatment area, none of the units have a true bypass which allows excess water to exit without contacting the treatment area. The significance of this observation will be discussed in later chapters.
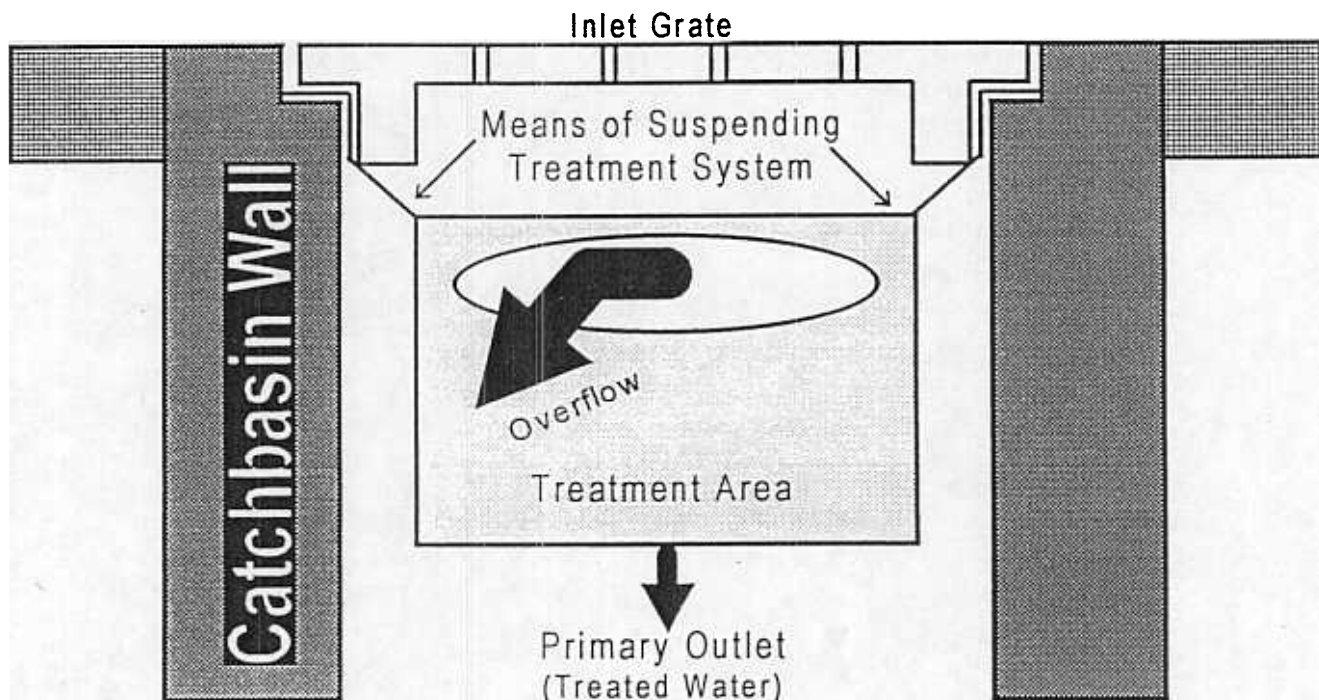


**Figure 1. Typical Features of a Catch Basin Insert**

## 1.6 INSERTS TESTED

Testing in the fall of 1993 was limited to locally manufactured inserts of vendors known to the CBIC. At that time the CBIC requested the participation of three vendors: Stormwater Services, Aqua-Net, and Enviro-Drain. Drawings of the basic configuration of each product tested are shown in Figure 2. More detailed descriptions of the specific configurations used during various stages of the pollutant-removal and hydraulic-performance experiments are provided in Table 1.
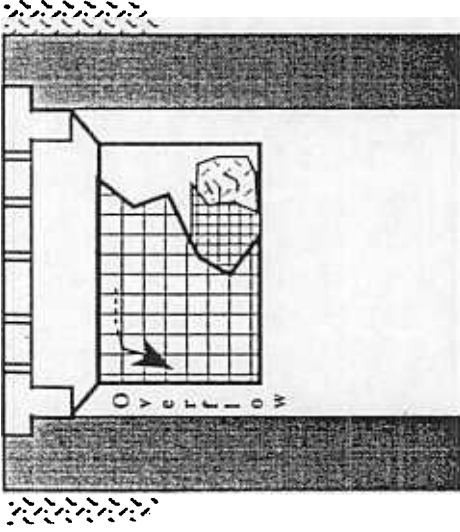
**a.** **Aqua-net Gullywasher Model 10001**
*Side view with cut-outs to show interior*
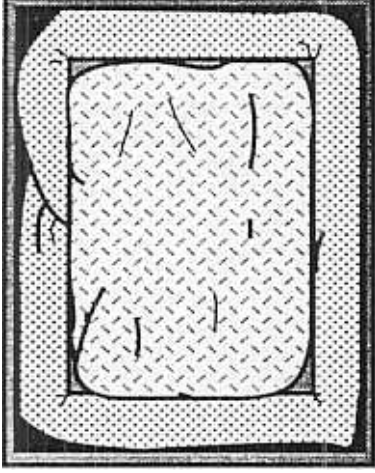
**b.** **Aqua-net Gullywasher Model 10003**
*Top view shows revised containment system*
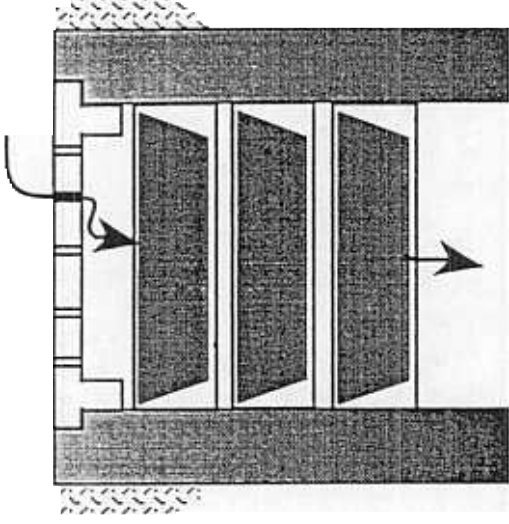
**c.** **Enviro-drain**
*Side view*
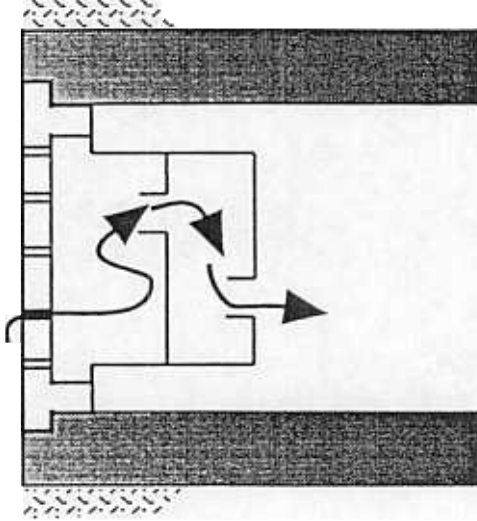
**d.** **Stormwater Services type I**
*Cross section*
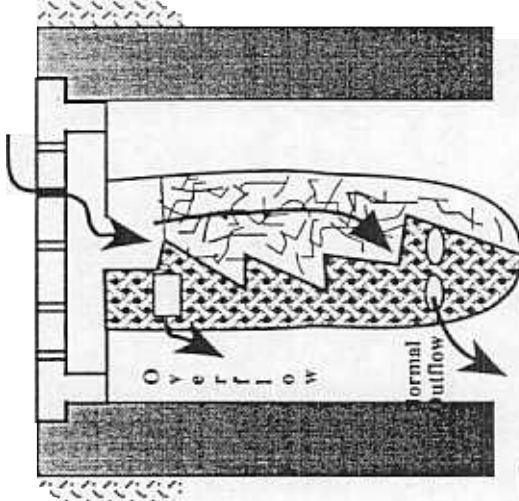
**e.** **Stormwater Services Type II**
*Side view with cut-outs to show absorbent*
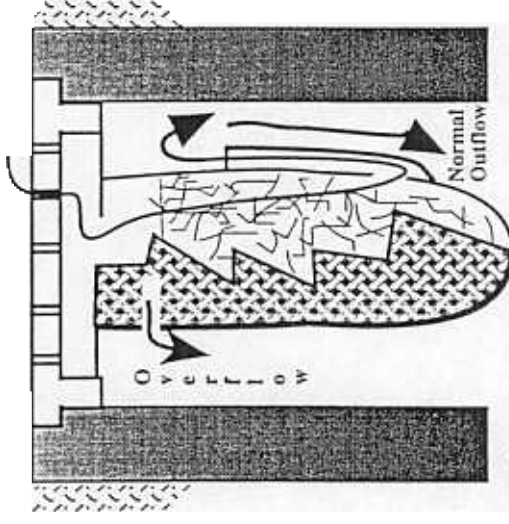
**f.** **StreamGuard (replaced e)**
*Side view with cut-outs to show absorbent*

**Figure 2. Basic Catchbasin Insert Configuration Used in the Study.**
Figure *a* through *f* illustrate the basic units used. More detailed descriptions
of these and other related configurations are listed in Tables 1 and 2.

# Figure 2. Detail Notes

a) <u>Aqua-Net Gullywasher Model 10001</u>: A wire mesh outer basket fitted with an inner basket made of fine stainless-steel screen. The inner basket contains an "onion sack" filled with an absorbant made from a wood by-product. The primary outlet is through the bottom of the sack, while high-flow relief is through the sides of the upper part of the wire mesh basket.

b) <u>Aqua-Net Gullywasher Model 10003</u>: A more advanced version of the "Gullywasher" described above. In this version, the stainless steel inner basket has been replaced with a second wire mesh basket. A long sock filled with oil-absorbing material is coiled between the inner and outer basket. As with the above product, an "onion sack" filled with absorbant is inserted in the bottom of the basket. The primary outlet is through the absorbant in the bottom and sides. High-flow relief is through the upper part of the basket.

c) <u>Enviro-Drain</u>: A system of up to three trays, each with solid sides and mesh bottoms. The trays may be filled with an absorbant, activated carbon, or used simply as a debris-catching screen. The screens may be changed to meet specific site conditions. The system is typically installed with the top tray in a screen-only configuration, and the second two trays filled with an absorbant. All components are stainless steel.

d) <u>Stormwater Services Type I</u>: A set of two interlocking trays that create standing water in which solids are allowed to settle. The overflow from the upper tray discharges to the second tray. The trays are molded in a standard size from recycled plastic. A variety of steel adapters allow the unit to be used in larger drain inlets.

e) <u>Stormwater Services Type II</u>: A filter fabric sack filled with a polypropylene absorbent. Primary discharge is through the small holes near the bottom of the sack. A secondary outlet is near the top of the device. This model was discontinued during the study.

f) <u>StreamGuard</u>: This product replaced the Stormwater Services Type II-O, with the principle difference being that the primary outlet has been routed through a pocket on the outside of the sack. A secondary outlet is still provided near the top of the device.

# Table 1. Configurations Used in Tests.

| VENDOR | DESCRIPTION OF CONFIGURATION | CODE | TESTS IN WHICH CONFIGURATION WAS USED | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
| | | | HYDRAULIC CAPACITY | | | PERFORMANCE | |
| | | | TREATMENT AREA | OVERFLOW AREA FRESH UNIT | OVERFLOW AREA SEASONED UNIT | SEQUENCE ONE | SEQUENCE TWO |
| Aqua-Net | Basket of Absorbent W (AbW) | AN-A | yes | | yes[2] | yes | |
| Aqua-Net | Basket, no AbW | AN-S | yes | | | yes | |
| Aqua-Net | Modified basket, with AbW | AN-Aa | | | | | |
| Aqua-Net | Modified basket with Supersorb™ | An-As | | | yes | | yes |
| Enviro-Drain | Coarse screen, shallow empty tray | ED-S | yes | yes | | | |
| Enviro-Drain | Coarse screen, shallow tray of AbW | ED-As | yes | yes | | yes | |
| Enviro-Drain | Coarse screen, deep tray with AbW | ED-A | yes | | | yes | |
| Enviro-Drain | Fine screen, deep empty tray | ED-Sd | yes | | | | |
| Enviro-Drain | Course screen, tray of AbW, bottom tray of activated carbon | ED-SAC | | | | yes | |
| Enviro-Drain | Course screen, two trays with AbW | ED-SAA | | yes | yes[2] | yes | yes[2] |
| Stormwater Services | Type I: Box unit, filter fabric in each box | SS-1 | | yes | | yes | |
| Stormwater Services | Type II: Sock with strips of polypropylene | SS-2O | | | yes[2] | yes | yes |
| Stormwater Services | Type II: Sock without polypropylene strips | SS-2 | yes | yes | | | |
| Stormwater Services | "StreamGuard" Modified sock with strips | SS-3 | | | | | yes |

1. Same as AN-S unit in a blind test.
2. Modified design from the units used in the other hydraulic or performance tests.

# CHAPTER 2 - POLLUTANT REMOVAL STUDIES

## 2.1 METHODS

The performance of selected inserts was determined in a laboratory setting using a bench-test facility that allowed captured stormwater to be sampled before and after passing through each insert. This bench testing was performed when the inserts were new, and later, after the inserts had been installed in the field. The weight and character of the material captured in the inserts while they were in the field was also used to understand the performance of the inserts. A concurrent study conducted by the Port of Seattle contributed to the study team's understanding of how well catch basin inserts remove pollutants. The procedures used during each of these studies are presented in the following sections.

### 2.1A Bench Testing

Pollutant-removal data were obtained by running stormwater through the inserts at a constant rate and analyzing samples collected both before and after the test water passed through the inserts. The test water used for the bench testing came from a stormwater vault which served an employee parking lot and commercial storage area. Particle size distribution data from samples of the test water indicated that virtually all of the solids in the test water were in the form of particles less than 50 microns in diameter. Particles of this size are generally classified as medium silt and clay. Oil and grease concentrations in the test water were near the detection limit of 5 mg/L.

Although the study team was unable to find urban runoff data which confirmed that the size distribution of the material used in the test was truly representative of stormwater which typically enters a stormwater treatment facility, it is assumed that the test water is typical of stormwater which has been "treated" by a drainage system with sumps below each drain inlet.

Prior to each bench-test session, the water in the vault was circulated for at least 1 hour to re-suspend sediment on the bottom of the vault. The test water was then transferred from the vault to a 460-gallon tank and transported by forklift to the bench-test facility. As soon as the tank was in place, a mixer was turned on to keep the particulate material in suspension. This mixer was kept in operation throughout the entire bench-test session. Figure 3 shows the principle components of the bench test facility with the mixing tank in place.

Once the mixing tank was in place, an insert was placed in the bench-test apparatus and the test water was adjusted to a rate of six gallons per minute. (This flow was judged to be reasonably representative of the average field conditions, being the average flow rate of the 6-month 24-hour storm event from a drainage catchment of 0.25 acres located in the Seattle area. See Appendix A for design flow calculations.) Before sampling, the water was run for three minutes to establish a state of equilibrium between the inflow and outflow.

**Figure 3. Bench Test Facility.** Prior to testing, stormwater was transferred from a wet vault to the mixing tank. The test water was pumped from the tank, through a flow meter and H-flume, to the catch basin insert via a Teflon-lined approach. A mixture of 50 percent used motor oil, and 50 percent diesel was added at the upper H-flume. Samples were collected below the upper H-flume and below the lower Teflon-lined collector.
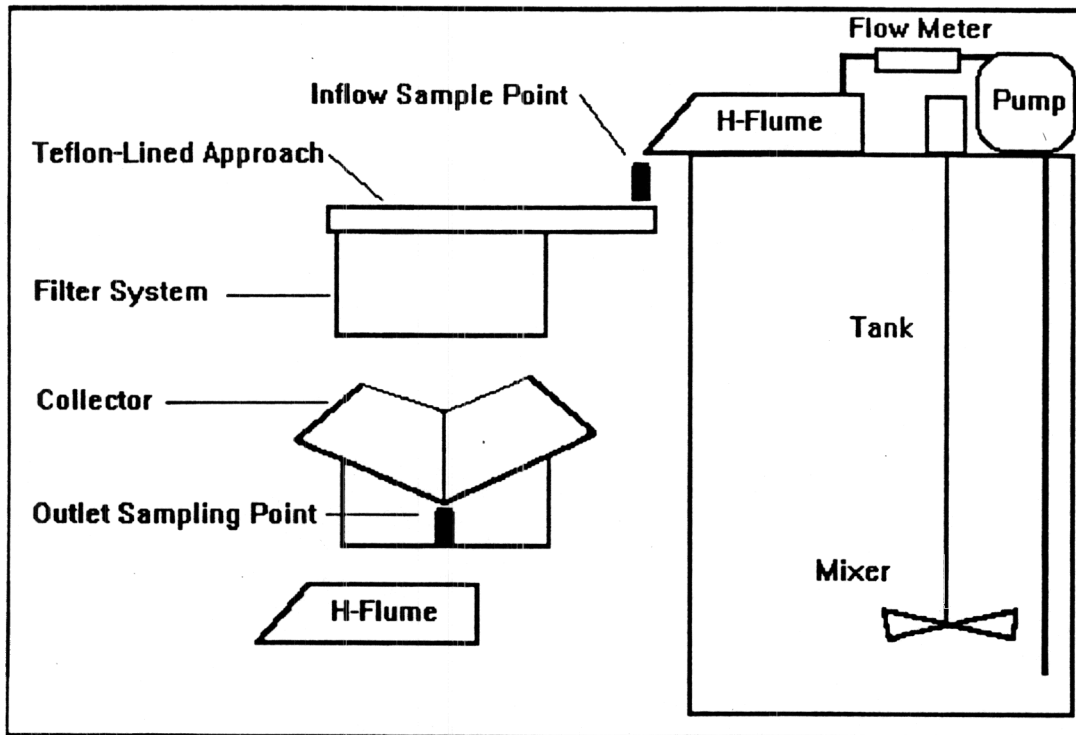


Since oil and grease concentrations were to close to the laboratory detection limit of 5 mg/l to allow meaningful analysis of insert performance, a mixture of 50 percent used motor oil and 50 percent diesel was introduced to the test water to achieve a concentration of five to ten times the detection limit. The mixture was introduced at the inlet flume by dripping it from a glass burette onto a piece of polypropylene material previously saturated with the mixture. This procedure was used in an attempt to introduce the mixture as a sheen rather than as droplets. As a result, oil and grease concentrations in the test water were at the high end of what the inserts would typically experience in the field.

After the three-minute "warm-up" period, influent and effluent samples were obtained over a two to three minute period. Between one and five inflow and outflow replicate samples were collected during each bench-test session. Note in Figure 3 that because the effluent sample is taken below the outlet of the insert, any effect of stormwater bypassing the treatment area is reflected in the effluent sample.

Samples were analyzed for: total suspended solids, turbidity, total phosphorus, oil and grease; total recoverable copper, lead, and zinc; and dissolved zinc. Zinc was the only parameter evaluated for its dissolved fraction since it was anticipated that it would be the only metal present at a concentration high enough to allow meaningful analyses.

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The samples were immediately put on ice after collection and were delivered to the analytical laboratory at the end of each day of bench testing. Turbidity values were obtained during each bench test using a portable turbidity meter.

## 2.1B  Field Conditioning and Follow-up Bench Tests

After the initial bench tests, during which the filters were in new condition, the inserts were placed in catch basins in the field where they were subjected to real-life conditions. The inserts were tested two or three times throughout each of two test sequences. A test sequence was defined as a set of alternating bench-test sessions and field-conditioning periods that extended from when the inserts were new to when they were no longer functional.

At the beginning of the study, the expected maintenance cycle of the inserts (both in terms of time and volume of water treated) was poorly understood. One vendor specified monthly maintenance while the other vendors based maintenance needs on the condition of the units. The field conditioning component of the study was intended, in part, to push the operational period of the inserts.

The details of each of the two test sequences follow.

<u>First Test Sequence</u>
The first sequence occurred from between early May 1994 and late August 1994, and focused on the ability of the inserts to remove fine sediments and associated particulate pollutants. During this test sequence a total of eleven inserts (representing seven distinct configurations) were installed across four field sites. Table 2A lists the configurations placed at the four sites. As noted in Table 2A, nine of the eleven inserts had adsorbent material intended to remove petroleum products. The remaining two products were configured primarily to remove sediment and associated pollutants.

The test sites included a maintenance shop yard, arterial road, park-and-ride lot, and industrial storage yard (marine container terminal). With the exception of the shop yard, one insert from each manufacturer was placed at each site; the absence of a third catch basin that was deep enough to contain an insert prevented the use of a third insert at the maintenance shop.

The area tributary to each of the catch basins at the field sites ranged from 4,800 square feet to 15,000 square feet. With the exception of the park-and-ride lot, the areas were about the same for each catch basin at each test site. Drainage areas are listed in Table 2.

During the first sequence, it was the intent of the study team to remove the inserts from the field for bench testing after every 1.5 to 2.0 inches of rainfall, and that each unit would be tested three to four times during each test sequence. In establishing this test protocol, it was assumed that the inserts would initially provide a high level of treatment, and that the treatment ability of the inserts would gradually decline over several months.

# Table 2. Configurations Used at Field Sites

## 2a. First Test Sequence

| TEST SITE | STORMWATER SERVICES | AQUA-NET | ENVIRO-DRAIN |
|---|---|---|---|
| Maintenance Shop Yard | Not tested at this site due to lack of suitable catch basin | Basket with Absorbent W (AN-A)<br><br>Tributary area: 7,000 ft2 | Coarse screen, and one tray of Absorbent W (ED-A)<br><br>Tributary area: 6,000 ft2 |
| Park-and-Ride Lot | Type II-O, sock with polypropylene strips (SS-2O)<br><br>Tributary area: 10,000 ft$^2$ | Basket with Absorbent W (AN-A)<br><br>Tributary area: 13,000 ft$^2$ | Coarse screen, two trays of Absorbent W (ED-SAA)<br><br>Tributary area: 10,000 ft$^2$ |
| Arterial Road | Type II-O, sock with polypropylene strips (SS-2O)<br><br>Tributary area: 5,500 ft2 | Basket without bag of Absorbent W (AN-S)<br><br>Tributary area: 4,800 ft2 | Coarse screen, two trays of Absorbent W (ED-SAA)<br><br>Tributary area: 5,000 ft2 |
| Industrial yard | Stormwater Services, Type 1 double box (SS-1)<br><br>Tributary area: 10,000 ft2 | Basket without bag of Absorbent W (AN-S)<br><br>Tributary area: 10,000 ft2 | Coarse screen, tray of Absorbent W, tray of activated carbon (ED-SAC)<br><br>Tributary area: 10,000 ft2 |

## 2b. Second Test Sequence

| Employee Parking Lot | Type 3 Sock (SS-3) | Modified Basket with Absorbant W (AN-Aa) | Catch basin and insert dropped due to the small drainage area. |
|---|---|---|---|
| Commercial Parking Lot | Type 3 Sock (SS-3) | Modified Basket with Supersorb (AN-As) | Coarse screen, two trays of Absorbent W (ED-SAA) |

In the end, units from three of the sites were evaluated twice after the new-condition tests. Units from the park-and-ride lot were evaluated a third time. Total aggregate rainfall for the four sites ranged from 2.83 to 4.07 inches. The period that each unit remained in the field ranged from 118 to 140 days. The details of each field-conditioning period are included with the data tables in Appendix B.

Second Test Sequence

The second sequence of tests was conducted from early December 1994 to early February 1995. Based on experience gained during the first sequence, the second sequence was modified as follows: the focus was shifted from particulate pollutants to petroleum hydrocarbons, and the targeted interval between bench-test sessions was reduced from 2 inches to 0.75 inches of rain. It was hoped that by reducing the interval between bench tests, the point at which the ability of the units to remove oil and grease decreased would be clearly identified.

Prior to the start of the second sequence the manufacturers were given the opportunity to provide their most current designs. Table 2B presents the configurations tested during the second test sequence. As illustrated by comparing Tables 2A and 2B, two of the manufacturers provided units that were different than those used during the first test sequence. Changes included increases in the flow path through the treatment area, creation of dead storage, and, for one of the products, introduction of an alternate absorbent. These changes are also reflected in Figures 1(b) and 1(f).

For the second sequence, the inserts were tested when new, then installed at two sites: an employee parking lot and a retail commercial parking lot (hardware store). Three different configurations (one from each manufacturer) were tested at each sites. The areas tributary to the catch basins were initially estimated to range from 13,000 $ft^2$ to 32,000 $ft^2$.

The inserts were bench tested two to four times after being placed in the field. Total aggregate rainfall for the two sites ranged from 1.30 to 4.55 inches. The details of each field-conditioning period are included with the data tables in Appendix B.

The number of bench tests for the inserts ranged from three to five, including the test when "fresh." The sequential bench tests were terminated for a particular unit when either a significant decrease in the hydraulic capacity of the treatment area was observed and/or a significant decrease in oil removal performance was observed. Testing was generally discontinued when either the removal efficiency was less than 50 percent or effluent concentrations were significantly above 10 mg/l.

## 2.1C  Weighing and Analysis of Captured Material

The following data were collected in conjunction with the bench-testing and field-conditioning activities: The wet weight of each filter was obtained shortly after each bench test to determine the maximum field weight maintenance staff would have to work with; dry weights of the inserts were obtained at the beginning and end of the second test sequence; the particle size distribution of both the test storm water and the material captured in the inserts during the "field-conditioning" was determined; and spent media and captured sediment were analyzed for pollutants which could limit disposal options.

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## 2.1D Port of Seattle Study

A related study was conducted by the Port of Seattle at one of its terminals. The objective was to determine, in a very approximate manner, whether placing an insert in a catch basin would, in combination with the sump, perform better than the sump alone.

The test was conducted at a 10-acre site where containers are stored and repaired. Inserts (Stormwater Services, Type I) were placed in seven catch basins; ten other catch basins without inserts served as the control. The test was conducted between early February and early July 1994. The sumps and inserts were cleaned at the beginning and end of the test period. At the end of the test period, the captured material was air dried and weighed. Further details of the methods used in this study are presented in Appendix C.

# 2.2 RESULTS AND DISCUSSION
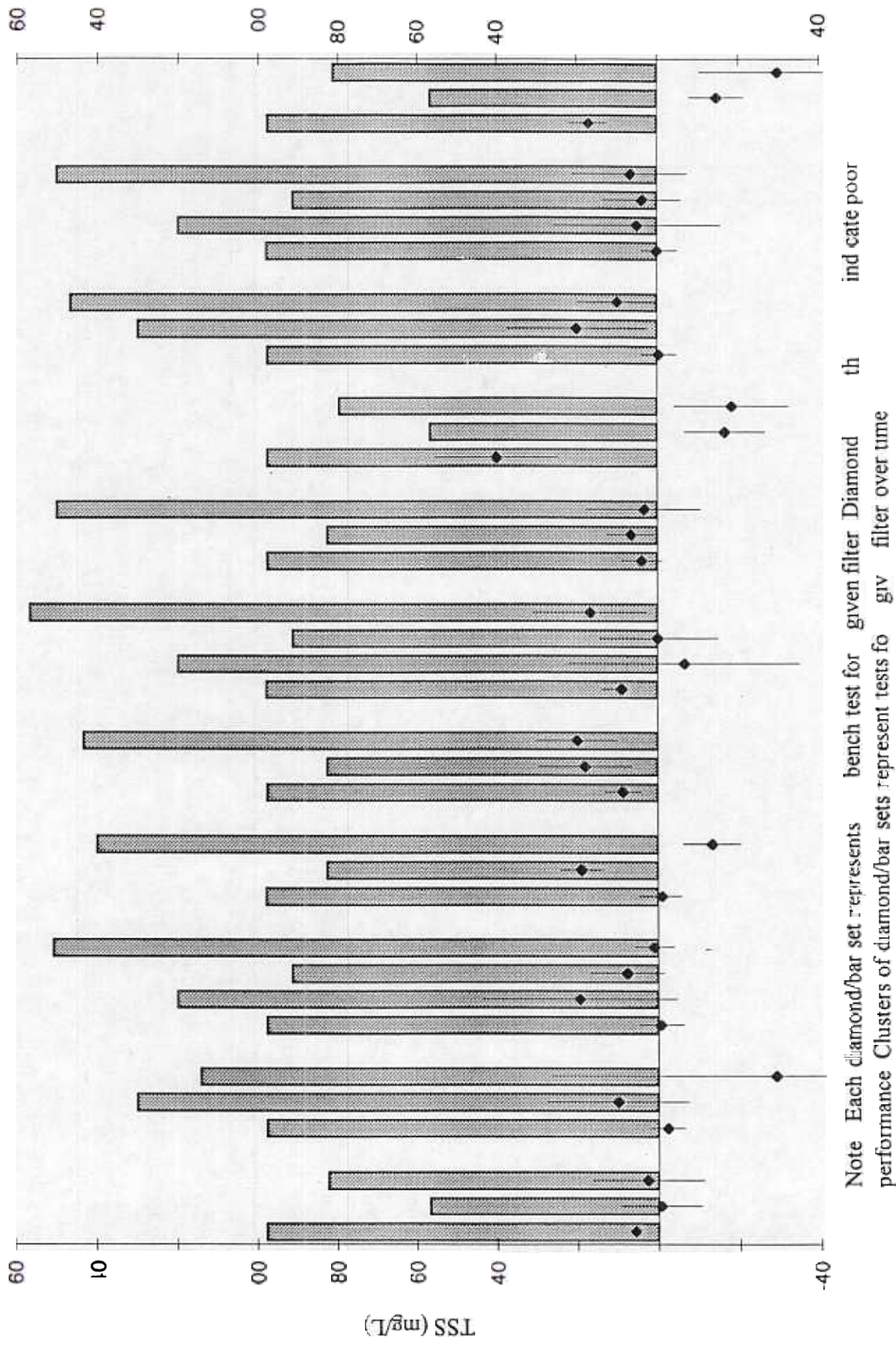
## 2.2A Suspended Solids

Bench Test Results
Total suspended solid (TSS) were sampled only during the first test sequence. During this sequence, the inserts achieved very modest TSS removals in the bench-test facility. This conclusion is illustrated in Figure 4 which compares the mean influent TSS to the mean quantity of TSS removed for each test. Inflow values during the bench test ranged from 52 mg/L to 157 mg/L for all tests. For any given day of bench testing the variability of the inflow was considerably less than for the entire study. Complete bench test data are presented in the tables in Appendix B.

In Figure 4, each vertical bar represents one bench test for one insert configuration. Each group of bars represents all tests for a particular configuration used in a specific field site. The manufacturer and configurations are not identified because of the lack of difference in their respective performances. The "diamond" associated with each vertical bar represent the change in TSS concentration. (Diamonds located near the "x" axis are indicative of low removal rates.) The mean inflow concentration is represented by the height of the bar. During all but two tests, the reduction in TSS was less than or equal to 20 mg/L.

During nearly half of the bench tests, the observed reduction in TSS was near zero mg/L, or was negative. All units exhibited negative removals during one or more bench tests. The negative removal efficiencies are believed due to a combination of two factors: sediment washout during the bench test, and the inherent variability in the laboratory and bench-test procedures.

Washout was observed during most bench test runs. During the flow stabilization period of three minutes, the turbidity of the water leaving the inserts increased temporarily. Although this initial "spike" of turbidity quickly attenuated (and was not included in the samples), it was apparent from visual observations that washout could have been occurring during the sampling period. Although observed only visually during the first test sequence, this "first flush" effect was characterized during the second sequence through the collection of turbidity data as soon as water began to leave the insert. First flush values were typically 20 NTU above values for samples collected after the three-minute "warm-up" period ranged. Outflow turbidity values after this stabilization period were always within plus or minus ten percent of the inflow values, indicating the inserts did not substantially reduce turbidity.

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**Figure 4  TSS Test Results.** Diamonds indicate the change in mean TSS concentrations in test water after passing through the inserts. Whiskers show how the 90% confidence intervals about the change bars are influ w concentrations

Note  Each diamond/bar set represents           bench test for    given filter  Diamond            th           ind cate poor
performance  Clusters of diamond/bar sets represent tests fo     giv    filter over time

Of significance, is the observation that washout occurred at a moderate flow rate of 6 gpm. This rate represents the average flow during the 6-month event from a catchment of 0.25 acres. Washout is likely to be even more of a problem during periods of intense rainfall. This observation suggests two possible design flaws in the inserts. The first flaw is the susceptibility of accumulated sediments to be re-suspended even at low flow rates. This re-suspension is caused by the energy of incoming water striking the treatment area. Some form of energy dissipation is needed between the grate and the treatment area. The second flaw is that a true bypass system is needed to divert flows that exceed the peak of the 6-month event; overflow areas that are an integral part of the treatment area do not provide sufficient protection of the treatment area during the high flows. The use of a bypass that limits the total flow to the treatment area should be considered in future insert designs.

## Table 3. Accumulation of Sediment at Field Sites

| LOCATION | VENDOR/UNIT | INITIAL DRY WEIGHT OF THE UNITS | DRY WEIGHT OF UNITS 120 DAYS IN FIELD | NET GAIN |
|---|---|---|---|---|
| Park-and-Ride | Stormwater Type II with polypropylene strips (SS-2O) | 6 | 6 | $0^2$ |
| | Aqua-Net with Absorbent W (AN-A) | 19 | 37 | $18^3$ |
| | Enviro-Drain two trays of Absorbent W (ED-SAA) | 66 | 68 | $2^3$ |
| Industrial | Stormwater Type 1 (SS-1) | 24 | 26 | 2 |
| | Aqua-Net, no Ab-W (AN-S) | 18 | 18 | $0^2$ |
| | Enviro-Drain with Absorbent W and activated carbon (ED-SAC) | 72 | 72 | $0^2$ |
| Maintenance shop | Aqua-Net with Absorbent W (AN-A) | 23 | 64 | $41^3$ |
| | Enviro-Drain with tray of Absorbent W (ED-A) | 17 | 29 | $12^3$ |
| Arterial road | Stormwater Type II with polypropylene (SS-2O) | 6 | 16 | 10 |
| | Aqua-Net, no absorbent (AN-S) | 19 | 25 | 6 |
| | Enviro-Drain two trays of Absorbent W (ED-SAA) | 66 | 81 | $15^3$ |

1. All units are in pounds.
2. Sediment was present in these units but the method of weighing carried sufficient uncertainty to mask the weight of the accumulated material which was likely less than two pounds.
3. Some absorbants did not completely dry and therefore this figure is an overstatement of accumulated material.

As previously stated, the study team sought to push the ability of the inserts beyond their expected maintenance cycle. For this reason, the above analysis presents a worst-case scenario since many of the inserts were at or beyond their useful life during the later tests. One would expect considerably better performance during the first set of bench tests when the filters were new, but the data from the new-condition test (which are represented by the first diamond/bar data set in each of the clusters in Figure 4) indicate the initial performance was generally no better than the performance later in the study. In a few instances, the performance of the inserts appeared to increase after the first field conditioning session. These small changes in apparent performance, however, are within the expected experimental error.

## Sediment Accumulation and Particle Size Distribution

While the inserts appeared to capture very little sediment in the bench test, they did capture at least some sediment in the field. Results of the before-and-after weighings ranged from 0 to 41 pounds over a period of 120 days. (Complete weight data are presented in Table 3.).

Although three units appeared not to have increased in weight, visual observations confirmed that the units had captured sediment. The discrepancy between visual observation and the weight lies with the uncertainty of the scale used to weight the inserts; weighing was originally intended only to provide information concerning maintenance needs. Although adequate for its original intended purpose, the scale used was not precise enough to reliably quantify sediment accumulation with an accuracy of more than a few pounds. In addition, the apparent quantity of sediment accumulated in the units with wood-fiber absorbents is probably overestimated because of the difficulty in completely drying these products at the end of the test period. Considering these sources of error and the relative small change in weight of the filters, the reported changes in gross weight should be treated only as a rough measure of the amount of material likely to be trapped under the field conditions studied. (According to one of the vendors, inserts installed in construction areas have captured as much as 100 pounds of sediment.)

The size distribution of the sediment captured by the units is similar to, or slightly coarser than, observed in street-surface contaminants. Figure 5 compares particle size distribution values from three studies (Sartor and Boyd, 1972; Aronson et al, 1983; Pitt, 1985), with those obtained from samples of the material captured by the inserts. The current study did not include analyses of the material entering the inserts in the field and therefore cannot report on the actual removal of these sediments; however, the comparison in Figure 5 seems to corroborate the observation in the bench tests that the inserts preferentially capture sand-sized sediment as opposed to silt and clay. A follow-up study, intended to examine the ability of the inserts to capture sand-sized particles will be conducted by Snohomish County Surface Water Management (Leif, 1995).

**Figure 5. Particle Size Distributions For Sediment Captured By CBIs Compared With Street Surface Contaminants.** "X s" indicate street-contaminant data. Material from inserts is indicated by circles.
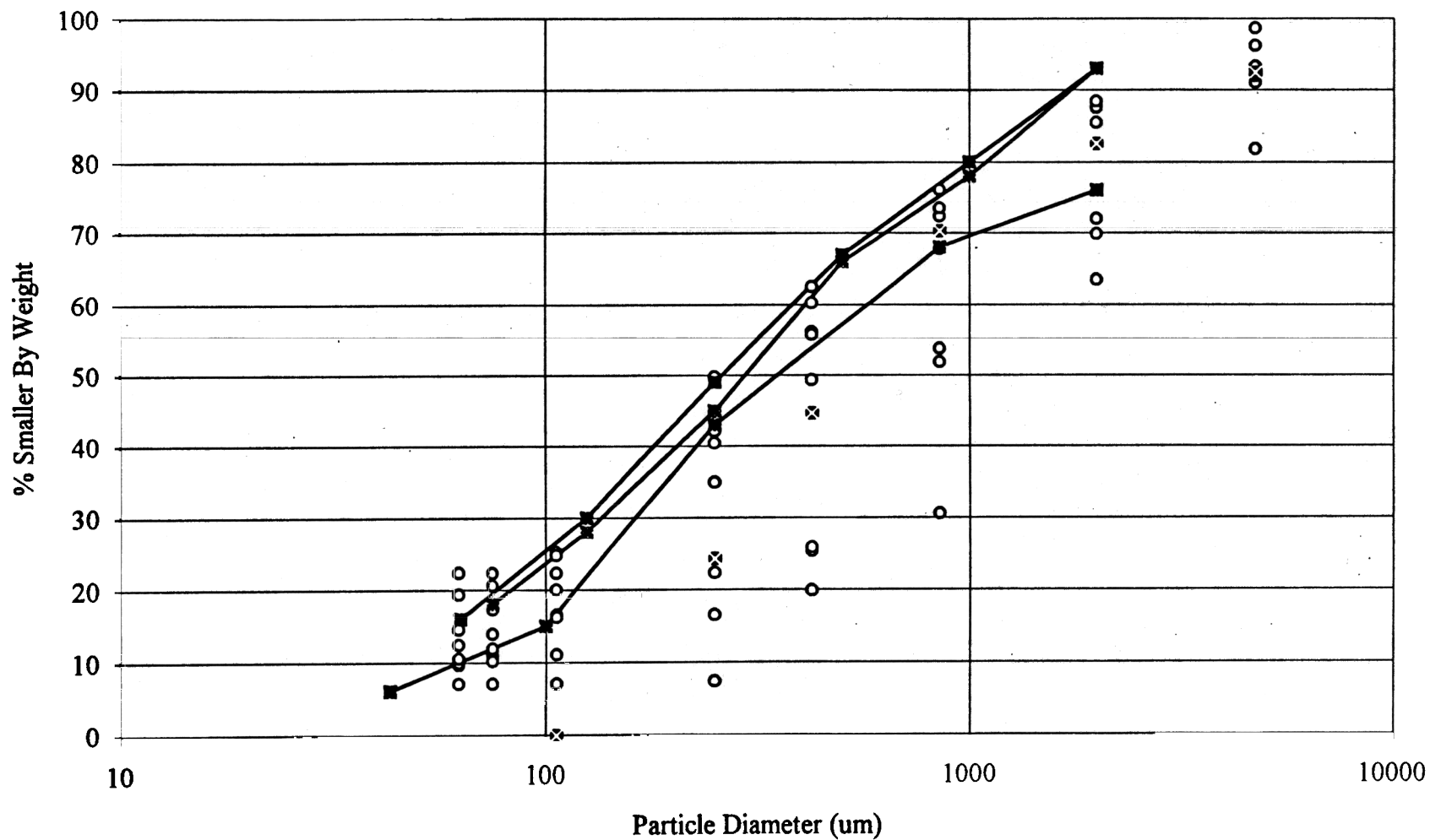
## Results of the Port of Seattle Study

The Port study addressed whether one type of insert (the Stormwater Services Type 1) plus the sump would result in significantly greater removal of pollutants than just the sump. This study was conducted on a 10-acre site with 17 catch basins.

The sumps without inserts removed 47 pounds of air-dried sediment over the five-month test period. During this period the inserts removed 20 pounds of sediment and the underlying sumps removed 27 pounds, for a combined total of 47 pounds. The analysis of the size distribution of the sediment in the inserts and sumps found that both removed similar material and that the captured sediment was essentially all sands and course material. This outcome indicates the inserts removed material that would have been removed by the sump. Only about five percent of the captured sediment were silt- and clay-sized particles as compared to the roughly ten percent fines indicated in the street-runoff studies presented in Figure 5.

Midway through the test it was realized that the test site possessed two attributes that may be unique. The results therefore, are not considered widely applicable at this time. First, the site was not completely paved, resulting in a considerable amount of sediment in the stormwater. Secondly, the site was washed daily during dry weather to reduce fugitive dust emissions. See Appendix C for further information on the study.

## Conclusions Regarding the Removal of Suspended Solids

- The inserts tested generally did not reduce the concentration of silt and clay sized particles by more than 20 mg/L and often exhibit removal efficiencies of zero under the conditions tested (moderate to high concentrations of particles less than 50 microns in diameter, delivered at a flow rate of 6 gallons per minute).
- Although the study was not designed to evaluate the ability of the inserts to remove materials greater than 50 microns, visual observations and particle-size distribution tests suggest that inserts are able to trap the courser materials typically found in street runoff. Thus, an insert intended to capture "raw" stormwater will likely achieve a higher removal efficiency than observed in the bench tests.
- The ability of the inserts to retain trapped material appears to be compromised in part by washout of previously trapped materials. Washout of trapped material may be reduced through the use of an energy dissipater and a high flow bypass (Other conditions which are likely to limit the performance of inserts are discussed in the following chapter on hydraulic performance.)
- None of the data indicate that inserts are able to reduce end-of-pipe concentrations under a normal sump-maintenance scenario; however, inserts may extend the maintenance cycle of the catch basin sumps by providing additional sediment storage. Routine maintenance of the inserts could be used to reduce the need for eductor-truck services.
- The inserts were unable to remove sediments which had been capture in, (and therefore were removed by) the sedimentation vault used to collect stormwater in the study. If the performance of other water quality facilities (ponds and vaults) is similar to the vault used in the study, it can be assumed that the insets do not perform as well as currently accepted treatment BMPs.

## 2.2B  Petroleum Hydrocarbons

First Test Sequence
During the first test eight inserts were configured to remove petroleum hydrocarbons. Figure 6 compares the influent and effluent concentrations for each test. In Figure 6 each diamond/bar set represents the results from one bench test on one insert configuration. Each group of bars represents all tests for a particular configuration. Except as noted below, the bar to the left of the group is the initial test, and each successive bar represents additional tests after field conditioning. The inserts ED-SAA, SS-20, and AN-A were each used in more than one site, but were only tested once in the new condition. New-condition results for these products are presented only with the first cluster for each product. The insert ED-SAC was not tested for oil and grease removal when in new condition.

In Figure 6, the bars represent the mean influent concentration and a diamond represents the mean effluent concentration. The error bars associated with the diamond represent the 90 percent confidence interval about the outflow concentration. The paired values above each diamond/bar set indicate the total number of days of field exposure and the total amount of rainfall prior to the bench test. A horizontal line at 10 mg/L represents the oil and grease concentration defined as "significant" in NPDES industrial stormwater permits.

An examination of Figure 6 suggests that the inserts were able to reduce oil and grease concentrations by between 30 and 90 percent when in new condition, and that removal rates were reduced to 30 percent or less by the first post-field conditioning tests. Only one of the units (SS-20) was able to reduce the oil and grease concentrations to below 10 mg/L, and this, only when the insert was new.

Two of the units, (ED-SAA and SS-20), exhibited increased removal efficiency (30 to 50 percent removal) during the last test after having been in the field for about four months. As with most of the units, the performance of these products had dropped off after the new-condition tests. Whether these changing removal rates are the product of changes in the nature of the filters during the field-conditioning period, or is simply indicative of the variability in the sampling procedure is uncertain. It is interesting to note that the insert designated AN-S, which was not configured to remove oil and grease and did not contain any oil-absorbing media, exhibited a calculated removal rate of 25 percent during the last test on that product.

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**Figure 6  Oil and Grease Results  First Test Sequence.** Boxes indicate mean outflow concentrations  Whiskers show the 90% confidence interval about the outflow concentrations  Bars show inflow concentrations.

Field exposure in days / rainfall.

Note: ED-SAC, ED-A, ANS and SS-1 were not tested when in new condition.  See Table 1 for key to insert configurations

Oil and Grease (mg/L)

ED-SAC    ED-A    ED-SAA    ED-SAA    SS-2    SS-2    AN-S    AN-A    AN-A    SS-

54 / 2.5    47 / 2.9    0 / 0    0 / 0    0 / 0    0 / 0    0 / 0    0 / 0    56 / 2.0    83 / 3.2

133 / 3.9    133 / 4.7    56 / 2.0    65 / 1.8    65 / 1.8    118 / 2.8    118 / 2.8    133 / 4.7    140 / 3.4    140 / 3.4

133 / 3.9

83 / 3.2    140 / 3.4    118 / 2.8    47 / 2.9

65 / 1.8    56 / 2.0    83 / 3.2

Second Test Sequence

The results from the first test sequence suggest the removal efficiency drops significantly at or before the units experienced 2 inches of accumulated rainfall. The second test sequence was conducted to better define the required maintenance frequency.

As in the first test sequence, the units were tested when new and then installed in the field. Once installed in the field the units were removed for bench testing after each 1/2 to 3/4-inch of rain.

Figure 7 presents the results of the second test sequence. The format of the presentation is the same as for the first-sequence tests shown in Figure 6. The data of only one Enviro-Drain unit are presented because it was discovered during the test sequence that the second unit was treating a substantially smaller area than originally estimated and therefore its performance could not be satisfactorily evaluated.

During the second test sequence, new-condition removal rates ranged from 21 to 85 percent. Referring to Figure 7, a comparison can be made between the apparent performance of the three configurations. Specific comments concerning each unit follow.

When new, the performance of the modified Aqua-Net units (AN-AW) and (AN-As) was somewhat lower than the performance of the original Aqua-Net units. The removal rate during the first sequence was nearly 60 percent, while the calculated new-condition rates for the two units during the second sequence were 21 percent and 35 percent. This outcome was surprising, given the increased filter surface area and the reduced opportunity for bypass in the new design. The apparent reduction in performance during the second sequence may be due to the substantially higher inflow concentrations used during the second sequence (67 and 85 mg/L compared to 34 mg/L in the first test). Leakage between the absorbent "socks" used on the sides of the insert was observed during the testing. This bypass may also have contributed to the modest performance of this insert.

Results from the second test of the Aqua-Net product designated AN-Aw suggested an 82 percent reduction in oil and grease. These data were surprising since blinding of the filter media was causing approximately one gallon per minute to bypass the treatment area via the high-flow outlet. In addition, the oil and grease concentration in the effluent was at or below, the 10 mg/L target threshold. The reason for this apparent increase in performance (or alternatively, the modest initial performance) has not been explained.

The second Aqua-Net configuration, designated AN-As, which used an alternative wood-fiber absorbent, remained fairly consistent throughout the second sequence. If we assume that the initial test, (which was conducted using relatively high oil and grease concentrations), contributed to the low initial performance, we might conclude that this insert maintained a removal capacity of around 35 percent.

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**Figure 7. Oil and Grease Results - Second Test Sequence.** Boxes indicate mean outflow concentrations. Whiskers show the 90% confidence interval about the outflow concentration. Bars show inflow concentrations.
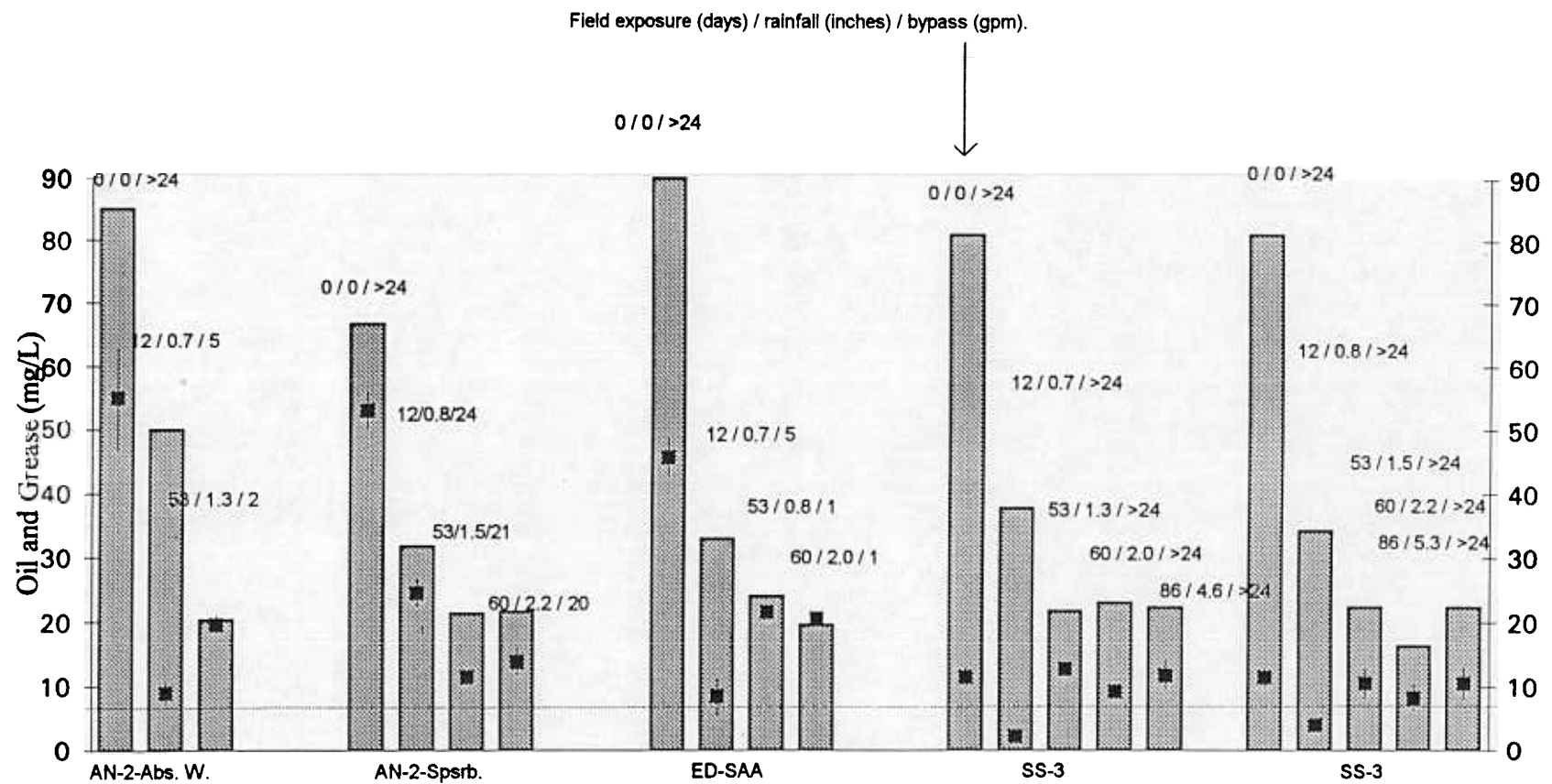
The operating instructions for the Aqua-Net units call for periodic removal and "shaking out" of the absorbent-filled bag. The purpose of this activity is to break up any crust which may form over the absorbent surface and improve contact between the absorbent and the stormwater. While this intermediate maintenance activity (which was not carried out during the study), is likely to affect the performance of the inserts once they have been installed in the field, it would not have affected the initial performance of the units when they were in new condition.

The Enviro-Drain unit (ED-SAA) failed to bring the oil and grease concentration to the 10 mg/L target level during the "new-condition" test, but met this treatment objective after the first field conditioning period. New conditions removal rates for the Enviro-Drain were around 50 to 60 percent. The unit appears to have performed well up to a rainfall depth somewhere between 0.7 and 1.3 inches, however, transporting the units from the field to the laboratory increased the hydraulic capacity of the insert; when observed in the field at the end of the first field-conditioning test, the upper absorbent tray was full of water even though it was not raining and there was no s no water entering the insert. Once at the test facility, the flow through the upper absorbent tray was measured at 4.6 gallons per minute. This observation raises concern over the potential effects (both positive and negative) of transporting the inserts to the bench-test facility.

The reduced filter capacity of the Enviro-Drain appeared to be due to clogging of the bottom screen of each tray, either by sediment or the absorbant used in the tray. A second problem which limited the performance of the Enviro-Drain was that the absorbant became covered with a thin layer of sediment and oil that prevented stormwater from reaching the absorbent. The layering was especially evident during dry weather when it formed a nearly impermeable crust. According to the vendor, this layering problem can be overcome by gently breaking up the crust between storm events. As with the Aqua-Net units, this intermediate maintenance step was not carried out during the field-conditioning periods.

The Stormwater Service units maintained removal efficiencies of around 50 percent, and outflow concentration near, or below 10 mg/L well after the third field conditioning period. These units were subjected to total of 4.5 and 5.2 inches of rain respectively (2.5 to 3.0 inches more than the other inserts) before a final test.

Performance of the Stormwater Services units differed between the two test sequences. During the first sequence the units performed very well when fresh, but their performance dropped significantly after 2 to 3 inches of rainfall. However, during the second sequence the units were still performing well after about 5 inches of accumulated rainfall. This difference is almost certainly due to the design changes made between the first and second test sequences. The design change thought to have the greatest impact on performance was the addition of a "pocket" on the exterior of the insert. This pocket allowed the outflow to be routed from near the bottom of the insert to an elevation just below the high-flow outlet (see Figure 1(f)). Since the filter fabric that these inserts are constructed from quickly becomes impermeable when installed in the field, the modification creates a dead storage area inside the unit and reduces the hydraulic head (and thus velocity), at the outlet. The creation of a dead-storage area increases the contact time between the stormwater and the absorptive media, and allows some gravitational separation of trapped oil and sediment. The reduced velocity around the outlet, combined with the low velocity in the dead